Reliability and Validity of the Standing Balance Assessment for Spinal Cord Injury (SBASCI)

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Abstract

Background: Standing balance has been reported as one of the major determinants of walking in Spinal Cord Injury (SCI). Standing Balance Assessment for Spinal Cord Injury (SBASCI) is a newly developed tool to assess standing balance in individuals with SCI which uses gradations of physical assistance and devices required to achieve standing. The purpose of the study was to establish interrater reliability and concurrent validity of SBASCI.

Method: 39 individuals with SCI were part of the study. Interrater reliability was established by correlating the scores of two raters using kappa statistics. Concurrent validity was evaluated by comparing scores between SBASCI and Berg Balance Scale.

Results: Inter rater reliability showed excellent value of 0.98 using Cohen's coefficient. The inter rater reliability for all the items of SBASCI ranged with a cohen's kappa coefficient form 0.37 to 0.97 (ICC 0.68 to 1.00) suggesting fair to excellent reliability. The concurrent validity shows estimated correlation ($r=0.9376$) at 95% confidence interval and was statistically significant ($p<0.05$)

Conclusion: The study established the psychometric properties of SBASCI and supported its concurrent validity and interrater reliability as a useful instrument to measure Standing Balance of individuals with Spinal Cord Injury

Keywords: *Spinal cord injury, standing balance, Validity, Reliability.*

Introduction

Balance is a central component for safe, optimal standing and walking functions. In fact, standing balance has been reported as one of the major determinants of walking in a spinal cord injury (SCI) population[1]. An appropriate assessment tool for balance control is necessary for examining the underlying reasons for balance impairments, for assessing changes in balance control, and for predicting future falls[2].

Functional tests of balance focus on maintenance of both static and dynamic balance, whether it involves a type of perturbation/change of center of mass (CoM) or during quiet stance [2]. Standing balance is determined as the measurement which is used for the assessing of the balance and its ability to perform functional activities in standing position[3]. Standardized tests of balance are available to allow allied health care professionals to assess an individual's postural control. Some functional balance tests that are available to be used in population with Spinal Cord Injury (SCI) are: Romberg Test,Functional Reach Test,Berg Balance Scale (BBS), Timed Up and Go Test, Balance Evaluation Systems Test (BESTest), Activity-based Balance Level Evaluation

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(ABLE) scale, Mini-Balance Evaluation Systems Test (Mini-BESTest). A recent review of measures to assess Standing Balance in SCI reports the need to develop a clinical tool to measure Standing Balance in this population including the factors required to achieve safe standing in varying environments[3].

Moreover, recent studies show that clinical measures of standing balance, such as the Berg Balance Scale (BBS)[4], correlate well with various walking aspects (speed, endurance and use of assistive devices)[5,6]. The main lacuna of the BBS is its ceiling effect. The BBS has also been unable to predict falls in this population and has yielded little information as to what could potentially be the underlying causes for the balance difficulties observed[6]. Further, MINI Bestest has also been recommended over BBS as no ceiling effect was observed. But the test has only been assessed in AIS D individuals who have the highest functional level in the SCI population[3].

Moreover, these scales do not take into consideration the use of assistive devices and orthoses by individuals with SCI, which is a very important factor to improve quality of life of this clientele. Standing Balance Assessment for Spinal Cord Injury (SBASCI) is a newly developed tool to assess standing balance in individuals with SCI. The SBASCI incorporates gradations of Physical assistance and devices used for Standing and has reported satisfactory psychometric properties of Content validity, construct validity and Internal consistency (described elsewhere).

In this study, we aimed to examine the concurrent validity and reliability of the SBASCI in spinal cord injury. The first aim of the present study was to investigate the interrater reliability of the SBASCI. The second aim was to examine the concurrent validity of SBASCI by comparing its scores to Berg Balance Scale. We expected a positive association with Berg Balance Scale (BBS) as this scale has also been utilized to measurebalance in persons with spinal cord injury.

Method

This study was approved by the Research review committee and institution's ethics committee of Amity University Uttar Pradesh and Indian Spinal Injuries Centre, Delhi, India

The study sample comprised of 39 participants with SCI, Age 16-60 years, ability to understand spoken English, C7- L5 Level of spinal injury, traumatic and non progressive spinal cord injury, varying degrees of incomplete to complete sensorimotor loss (AIS A-D), ability to stand at least for 10 seconds with assistive devices (with appropriate orthoses and/or physical assistance). Subjects were excluded if they demonstrated- Inability to follow 2 step commands, any neurological, cardiovascular, orthopedic problem limiting the spinal weight bearing and excursion and Other concomitant neurological conditions in addition to SCI.

Procedure: SBASCI and BBS was administered on 39 participants with SCI. Baseline information comprising name, age, gender, time since injury, Neurological level of lesion, AIS grades, assistive devices used, Lower limb orthoses and duration of standing training rehabilitation was noted. Written informed consent was taken from all the participants for inclusion in the study. The participants were asked to perform the items of the scale, and the score sheet was filled accordingly.

Inter rater Reliability: Two physical therapists- One principal investigator and other Physiotherapist with more than 5 years of experience in Spinal Cord injury rehabilitation were part of this procedure. Both were trained in the standardized procedure of the scale. Patient were assessed only once for their balance score on BBS followed by SBASCI. The patients were assessed once to avoid any bias due to the rehabilitation they were receiving to improve their standing balance and thus avoid affecting the scores. The two therapists alternated between instruction/demonstration and observing the patient. Both were unaware of each other's rating on participants. Both the scores were entered on an excel sheet. The whole procedure took approximately 30 minutes.

Concurrent Validity: For evaluating concurrent validity, Scores on SBASCI wee compared with those of BBS on 39 participants with SCI with varying levels of standing balance impairment. The total score on BBS was correlated with SBASCI total score using Spearman rank correlation analysis. All the participants involved in inter rater reliability were administered BBS along with the SBASCI by the principal investigator.

Instruments: The BBS is a performance-based instrument originally developed by Berg et al [7] for assessment of functional balance in older adults. The BBS assesses performance on five levels, from 0 (cannot

perform) to 4 (normal performance), on 14 different tasks involving functional balance control, including transfer, turning and stepping, giving a score between 0 (poor) and 56 (normal). It takes 15–20 min to complete.

SBASCI is a newly developed performance-based ordinal scale that includes 22 items. Each item has Score ranging from 0-4 with 0 indicating lowest level of function and 4 indicating highest level of function. Each item has maximum score of four indicating subjects' ability to perform the activity independently (based either on time constraints, requirement of Physical assistance or distance/range required) and a minimum score of zero indicating inability to do the activity. Minimum and Maximum score of SBASCI is 0 and 88 respectively. The equipment required for the administration of the SBASCI is one standard chair, Parallel bars/ Walker/ Crutches/canes, Lower limb orthoses used by the individual (KAFO, AFO, Gaiters/ Knee immobilizers), a measuring tape, a stopwatch and a foot stool. These equipments are generally easily available in any clinical setting. The time taken to administer all items of SBASCI ranged from 15-20 min.

Results

Descriptive statistics was used to analyze the demographic characteristics of participants (mean, standard deviation- SD and counts percentage). The associated SBASCI scores along with BBS scores (mean, SD) has been shown as per the neurological level of injury, AIS grades, walking aids and orthoses (Table 1).

Interrater Reliability: The study results generated from a sample of 39 subjects from two different raters using 22-item SBASCI. The overall score of the 22-items been captured for the two raters and they are summarized and analyzed between two raters. The agreement statistics been generated between the two raters using kappa coefficient and with agreement plots[9]. All the study results are generated using SAS software with 9.4 version.

From Table 2, the overall score between two raters is tested. The simple and weighted kappa generated are 0.88 & 0.98 which shows a perfect agreement between two raters. The weighted kappa calculated based on Quadratic (based on Fleiss-Cohen) weights.

Likewise, for each item (Item01- Item22) of the SBASCI scale been tested for kappa and weighted kappa been calculated between the two raters. Cohen's Kappa is considered for calculating simple and weighted kappa. The inter rater reliability for all the items of SBASCI ranged with a cohen's kappa coefficient form 0.37 to 0.97 (ICC 0.68 to 1.00) suggesting fair to excellent reliability.

An agreement plot has been plotted between two raters (Figure 1). From the plots, the visual representation of the agreement shows that there was a large amount of exact agreement. Most of the scores show exact agreement and very minimal partial agreement and very few with no agreement for both simple and weighted kappa's coefficient.

Concurrent Validity: All correlations between the 22 item SBASCI and Berg Balance Scale were found to be statistically significant ($p < 0.05$), as shown in Table 3. The concurrent validity, estimated correlation ($r=0.9376$) at 95% confidence interval is approximately [0.883;0.967] ,implying that the actual correlation between the measures lies between those two values. Finally, we desired to calculate coefficient of determination (validity coefficient)which is 0.988 between the two scales (significant at $p<0.05$). The fisher Z-value between the SBASCI score and BBS scale score is 1.73 and show statistical significance ($P<0.0001$). The correlation coefficients of other demographic parameters by their pre-defined categories namely Neurological level of lesion and ASIA Impairment grades (AIS grades)are calculated and the results show high significance effects for all categories, except for AIS Grade D, which shows moderate correlation ($r=0.60$) and doesn't show statistical significance ($p=0.3270$). The other categories showed the statistical significance ($P <0.0001$). A scatter plot (Figure 2) with regression line is plotted to understand the correlation of overall score between SBASCI and BBS.

Table 1: Baseline Characteristics of study sample (N=39)

Variables	Category	n (%)	Mean	SD	SBASCI score Mean (SD)	BBS score Mean (SD)
Age	-	39	29.4	10.9	48.4 (26.7)	22.1 (15)
Gender	Males	32 (82.1)				
	Females	7 (17.9)				
Neurological Level	Cervical	10 (25.6)			25.2 (15.5)	10.6 (5.9)
	Thoracic	20 (51.3)			51.8 (26.3)	26.2 (16.8)
	Lumbar	9 (23.1)			62.2 (22.2)	26 (9.8)
AIS Grade	A	21 (53.8)			43.0 (26.0)	19.2 (15.1)
	B	5 (12.8)			40.8 (25.7)	18.6 (14)
	C	8 (20.5)			42.4 (23.1)	19.2 (8.6)
	D	5 (12.8)			80.6 (7.5)	41 (6.8)

Table 2: Interrater reliability Statistics for SBASCI

Statistic	Values	Asymptotic Standard Error	95% CI	p-Value*
Simple Kappa	0.8824278	0.012906	[0.857 ; 0.908]	<.0001
Weighted Kappa	0.9834898	0.002249	[0.979 ; 0.988]	<.0001

Weighted Kappa calculated based on Quadratic (based on Fleiss-Cohen) weights * : p value calcualted based on Kappa Test

Table 3: Correlation between scores of SBASCI and BBS

Group	N	Simple Correlation	Z-Value
Overall Sample	39	0.93902	1.72973*
Neurological level			
Cervical	10	0.97554	2.19577*
Thoracic	20	0.93710	1.71370*
Lumbar	9	0.87398	1.34969*
AIS Grades			
A: Complete	21	0.91930	1.58448*
B: Sensory Incomplete	5	1.00000	
C: Motor Incomplete	8	0.89822	1.46293*
D: Normal	5	0.60000	0.69315

Significant at $p<0.05$

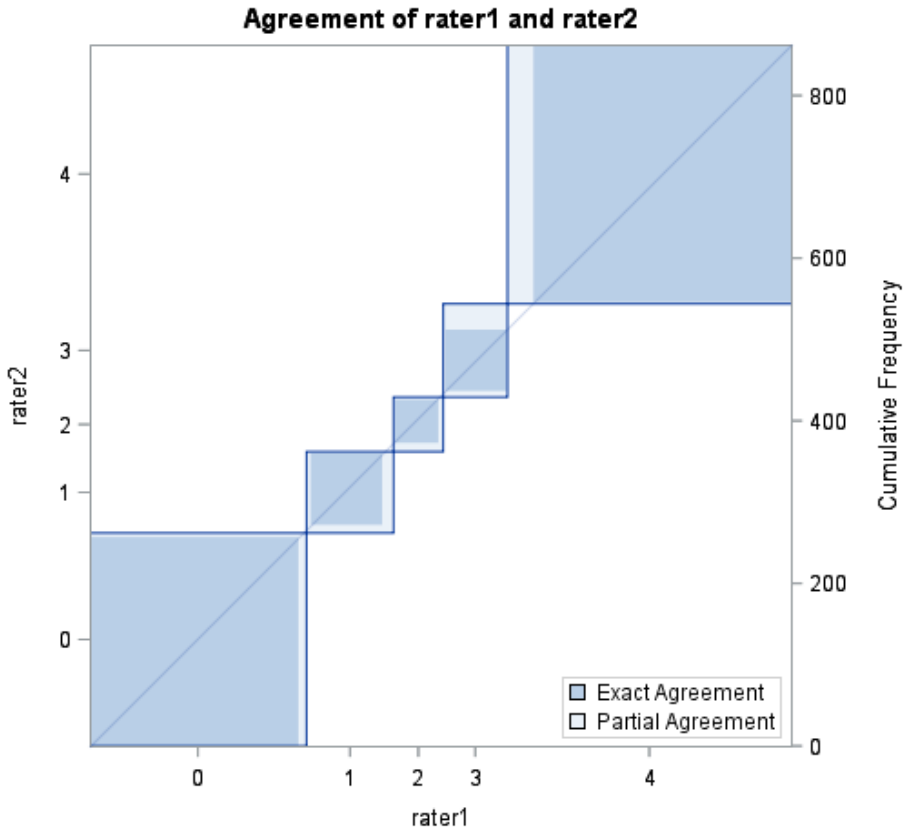

Figure 1: Agreement Plot - Simple Kappa - Agreement between rater1 vs rater2

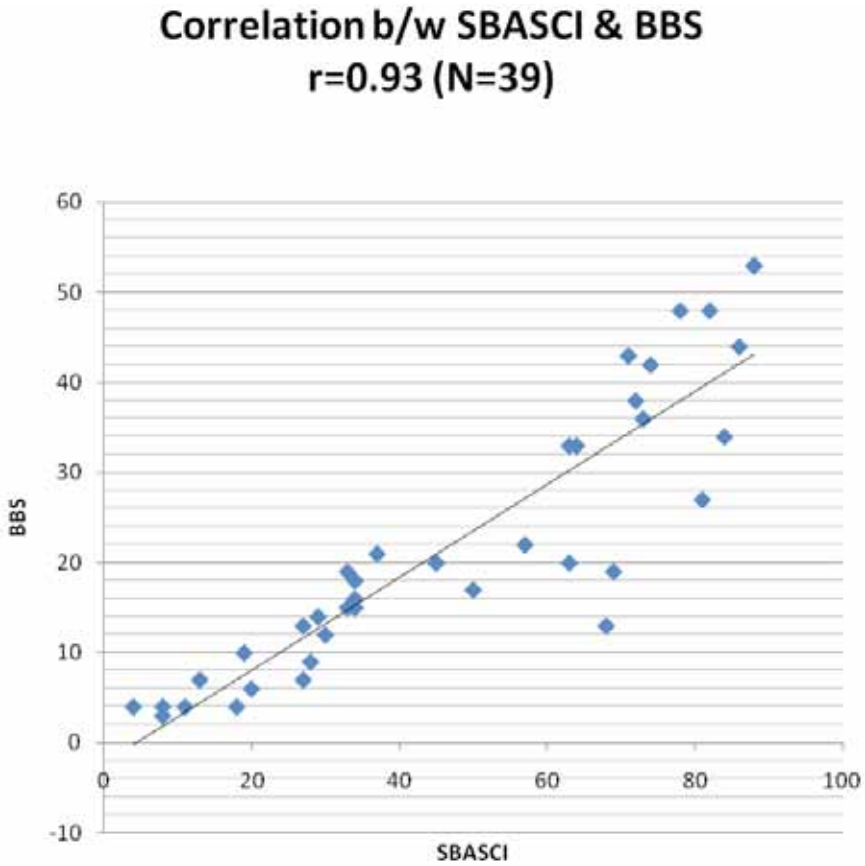

Figure 2: Concurrent validity of SBASCI with BBS

Discussion

Standing Balance Assessment for Spinal Cord Injury (SBASCI) is first of its kind which is developed only for subjects with Spinal cord injury having varying levels of standing abilities and balance. As the rehabilitation for a subject with SCI progresses from acute to chronic stage, there is gradual improvement in the sensorimotor function along with use of orthosis for standing progressing from O-frame to Parallel bars to walker to crutches and canes. But there is no clinical tool which can assess the patient's abilities on these domains of standing so as to give a clear understanding of patient's improvement on standing which will ultimately prepare the patient for Gait Training. **SBASCI** is one such tool in which the score improves with the improvement of sensorimotor function and use of orthosis thus showing hierarchy as per the level of Spinal Cord Injury. Other clinical scales which were not developed for this population do not consider the requirement of orthosis as well as lack of sensorimotor function seen in Spinal cord injury subjects. Thus, SBASCI is a newly developed clinical tool exclusively for Subjects with Spinal Cord Injury that will assess standing balance function of this population in various domains and will also show improvement in score as per the level of injury, severity and chronicity of injury.

The study aimed to produce psychometric properties of interrater reliability and concurrent validity of SBASCI on individuals with spinal cord injury. The initial psychometric properties of content validity, construct validity and internal consistency have been established (described elsewhere).

Inter rater reliability showed excellent value of 0.98 which is better than the existing tools to measure standing balance mainly Berg Balance Scale and MINI Bestest. (BBS - 0.84; MINIBestest-0.96).

The concurrent validity of the SBASCI was confirmed by significant positive correlations with scores on the Berg Balance Scale indicating that a person with higher BBS score is also likely to have a higher SBASCI score. The strong agreement between the SBASCI total score and BBS total score suggests that the SBASCI measures aspects of balance functionally relevant to individuals with SCI.BBS was chosen for correlation with SBASCI because studies have reported assessment of balance impairment in spinal cord injury using BBS. Though the scale does not permit use of assistive devices and has only been used in AIS C & Dcases, still it is the most frequently used tool to assess balancein the population. There is no Gold standard tool to assess standing balance in this population. There are few items in BBS hat assess standing control of balance and thus if the scores on BBS are comparable with those on newly established SBASCI, it would help to establish concurrent validity of SBASCI.

Also there is significant correlation of SBASCI scores with that of BBS with reference to Neurological level of Injury and Asia Impairment Grades (AIS)(Table 3). This indicates that the subjects with cervical level of injury with maximum functional restrictions have minimum scores on SBSCI and those with Lumbar level of Spinal injury with minimal functional impairment will have better balance score as compared to cervical and thoracic group. Furthermore, the scores on SBASCI also shows an increasing trend as the AIS grades of individuals with SCI progress form AIS A (complete injury) to AIS D (recovered motor control)(Table 1). This shows the applicability of SBASCI in population with Spinal injuries.

Future Scope: Future studies can be done to see the effects of abalance improvement protocol on scores of SBASCI, thus serving a key factor in goal planning for rehabilitation.

Study Limitations: The data was collected only from one specialised centre, and non traumatic cases were not part of the study.

Conclusion

The findings of this study established the psychometric properties of SBASCI and supported its concurrent validity and interrater reliability as a useful instrument to measure Standing Balance of individuals with Spinal Cord Injury. This new cost effective clinical measure will prove to be a valuable tool for documenting and planning appropriate standing balance training protocol in SCI and thus improving Quality of life by improving balances an important determinant of functionality.

Declaration of Interest: The scale named STANDING BALANCE ASSESSMENT FOR SPINAL CORD INJURY (SBASCI) is registered as a Copyright work with the Government of India with Registration no. L-85102/2019.

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Ethical Clearance: Taken from Institute Ethical Committee of Amity University and Indian Spinal Injuries Center, India.

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